Climate Change and the Olympic Coast: Interpreting Potential Futures

A presentation to the OCNMS Sanctuary Advisory Council
15 March 2013

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(on behalf of the OCNMS Climate Change Assessment Working Group)

Sea Grant Washington

CLIMATE IMPACTS GROUP
Climate Science in the Public Interest

Goals

- Provide a status update on the project (5 min)
- Provide an overview of some results and conclusions (15 mins)
- Place into context of adaptation and risk reduction (10 min)
- Outline some continuing steps (5 min)
- Questions (20 min)

Motivation and Background

- At the request of the Office of National Marine Sanctuaries (ONMS), develop *Climate Change Site Scenario* that describes what the site and its environs may look like in 50 to 100 years
- Guidance from the ONMS Climate-Smart Sanctuaries program states that the draft *Climate Change Site Scenario* should:
  - Be based on best available information, including historic baseline information, recent resources assessment(s), and any climatologies, models, or forecasts available for the site and its surrounding region;
  - Use the best local expertise;
  - Provide for the involvement of stakeholders, including an advisory group if present;
  - Provide for other public review; and
  - Undergo a rigorous peer review process.
- The Site Scenario is followed by the development of a Climate Action Plan

~28 Working Group Contributors representing ~13 separate entities or agencies…

Name	Affiliation	Title	Role	Writing Assignments
Ian Miller	WA Sea Grant	Coastal Hazards Specialist	Editor, Lead Physical, Author	SST, SLR, Storms
Caitlin Shashido	WA Sea Grant	MMA Candidate	Lead Biological, Author	Plankton, Bivalves
Lara Whitely Binder	Climate Impacts Group	Outreach Specialist	Editor, Lead Sensitivity, Author	Sensitivity, Adaptation
Amy Snover	Climate Impacts Group	Co-director, Research Scientist	Editor, Review/Consult	
Liam Antrim	Olympic Coast NMS	Resource Protection Specialist	Editor, Review/Consult, Author	OCNMS Description
Carol Bernthal	Olympic Coast NMS	Superintendent	Review/Consult	
Ed Bowlby	Olympic Coast NMS	Research Coordinator	Review/Consult	
Steve Rubin	US Geological Survey	Fisheries Biologist	Lead Biological, Author	Fish
Brian Bylhouwer	Simon Fraser University	MS Candidate	Author	Ocean Currents
Steven Fradkin	Olympic National Park	Coastal Ecologist	Review/Consult	
Jennifer Hagen	Quileute Nation	Marine Biologist	Review/Consult	
Hillary Burke			Author?	Sensitivity, Adaptation
Tom Mumford	U Washington, OCNMS SAC		Author, Lead Biological?	Algae/Seagrasses
Jan Newton	U Washington, OCNMS SAC	Principal Oceanographer	Review/Consult	
Sandra Brooke	Marine Conservation Biology Institute, OCNMS SAC	Director, Coral Conservation	Author	Deep Water Coral
Tom Connolly	U Washington	PhD Candidate	Author	Anoxia/Hypoxia
Nick Bond	U Washington, JISAO	Research Meteorologist	Review/Consult	
Peter Hodum	U Puget Sound	Professor	Author	Seabirds
Sean McDonald	U Washington	Faculty, Program on the Environment	Author	Crustaceans (Crab)
Deanna Lynch	US Fish and Wildlife	Fish and Wildlife Biologist	Author	Sea Otters
Ingrid Tohver	Climate Impacts Group	Research Scientist	Author	Hydrology
Helen Berry	WA Dept Natural Resources		Review/Consult, Author	Algae/Seagrasses
Julie Keister	U Washington		Review Consult	
Terrie Klinger	U Washington		Review/Consult	
Frank Shipley	US Geological Survey	Senior Scientist	Consult	
Lyman Thorsteinson	US Geological Survey		Review/Consult	
Adrienne Sutton	NOAA PMEL	Postdoctoral Researcher	Author	OA
Nancy Elder	USGS	Fisheries Biologist	Author	Urchins

…who have contributed an estimated 1500 hours to produce ~200 pages of analysis after reviewing ~700 manuscripts or reports

Ladies and Gentleman, I am please to present to you:

citation

Marine Sanctuaries Conservation Series (ONMS-13-01)

Climate Change and the Olympic Coast National Marine Sanctuary: Interpreting Potential Futures

U.S. Department of Commerce
National Oceanic and Atmospheric Administration
National Ocean Service
Office of National Marine Sanctuaries

March 2013

http://sanctuaries.noaa.gov/science/conservation/cc_ocnms.html

5 Major Sections

People
Purpose
Context

5 Major Sections

Physical Projections:
Temp
Acidification
SLR
Storms
Upwelling
Hypoxia
Hydrology

5 Major Sections

General Ecological Responses: Ecosystem & Habitat Scale

5 Major Sections

Possible Species Responses:

- Phytoplankton
- Zooplankton
- Marine Algae
- Deepsea Corals
- Mussels
- Urchins
- Dungeness Crab
- Fish
- Seabirds
- Sea Otters/Pinnipeds
- Cetaceans

5 Major Sections

Adaptation Framework:

Essentially

Things to think

About and questions

To ask regarding

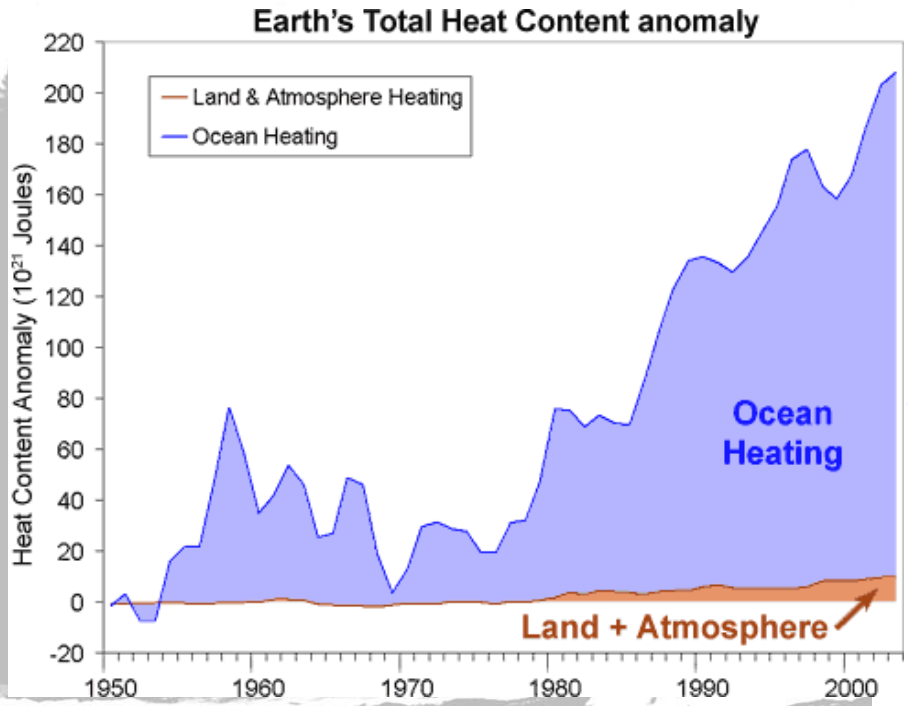
Adaptation in a

Natural system

“Additional Edits Expected”

- Current version has passed through internal and external (anonymous) review
- Current version IS available on-line, and content and conclusions will not change.
- However, a “final” version will incorporate minor word-smithing, addition of some references, perhaps the addition of very selected clarifying information (ppm conversion example)

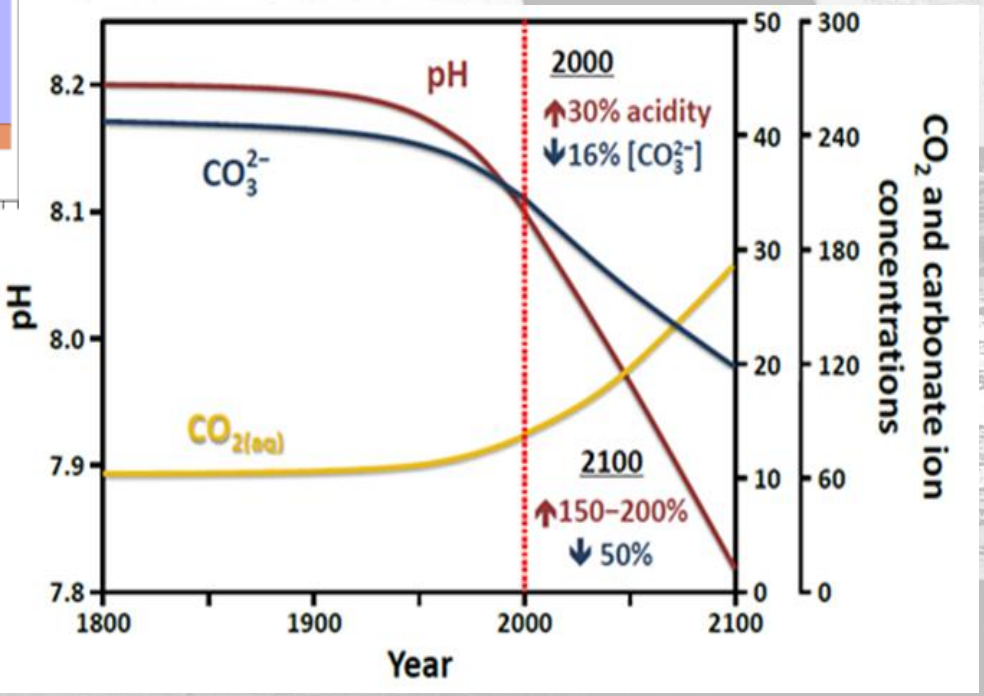
Results and Conclusions: The two drivers of change



Cook (2010) with data from Murphy et al. (2009)

Heat Budget Imbalance

Shifting CO_2 Equilibria

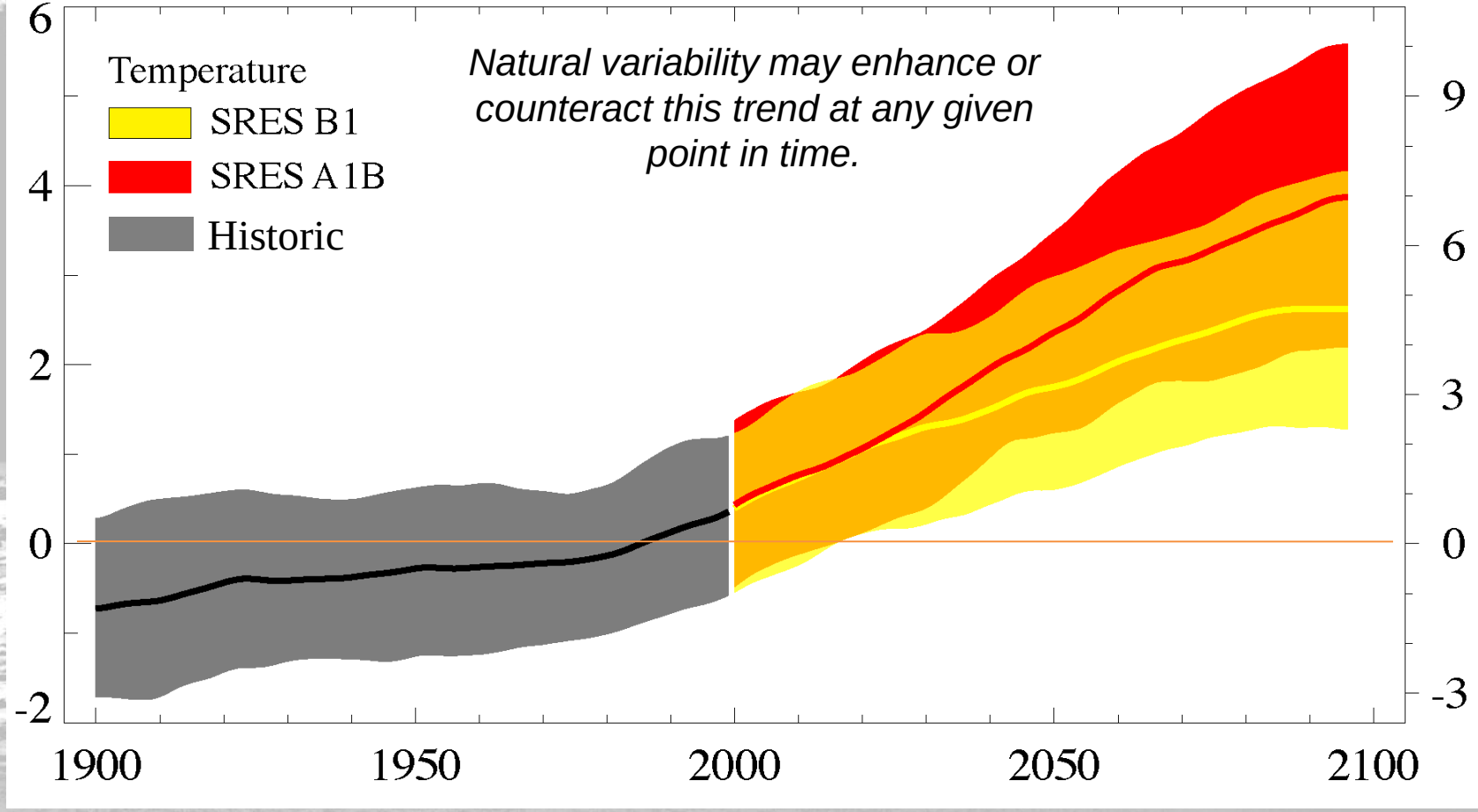


Simone Alin, NOAA PMEL; adapted from Wolf-Gladrow et al. (1999)

Projected Increases in Annual PNW Temperature

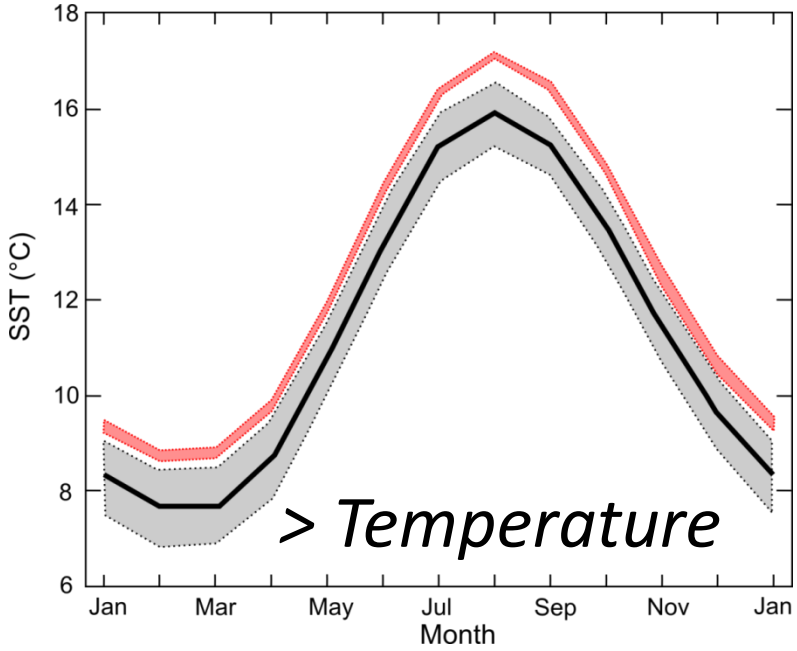
** Relative to 1970-1999 average*

2020s	+2.0°F *(1.1-3.4°F)*
2040s	+3.2°F *(1.6-5.2°F)*
2080s	+5.3°F *(2.8-9.7°F)*



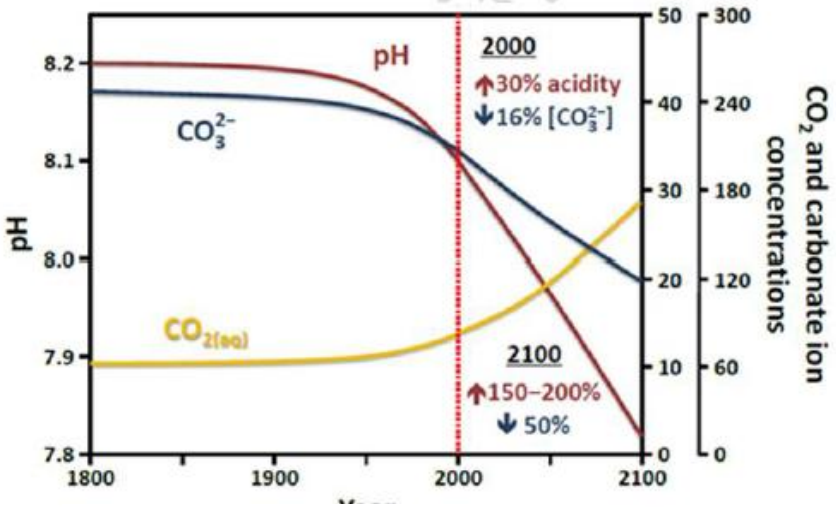
Mote and Salathé, 2009

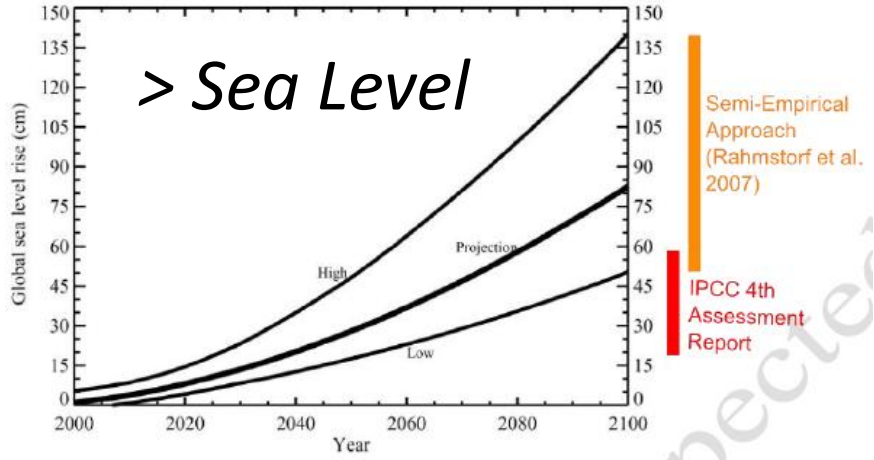
Physical Drivers



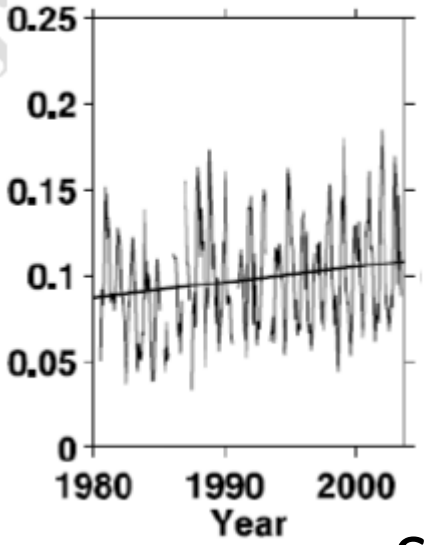
> Temperature

> "Corrosive Water"





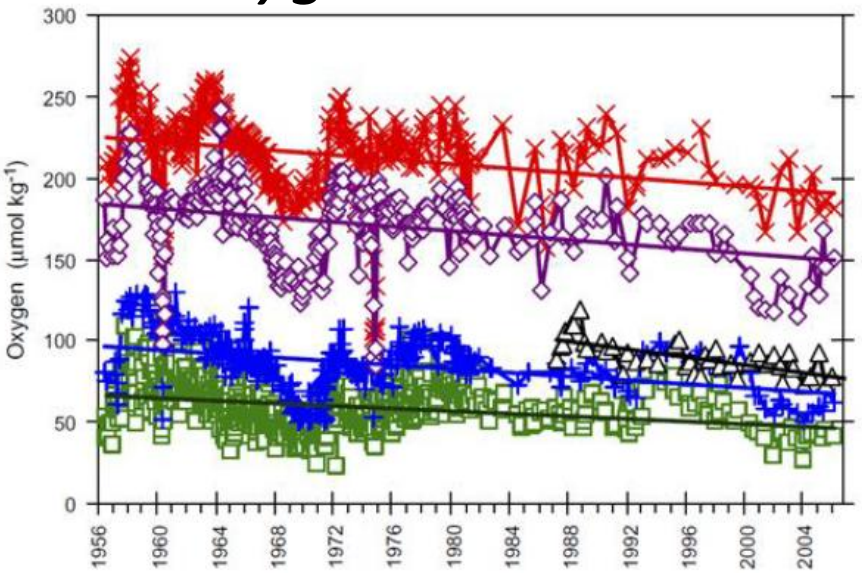
> Sea Level

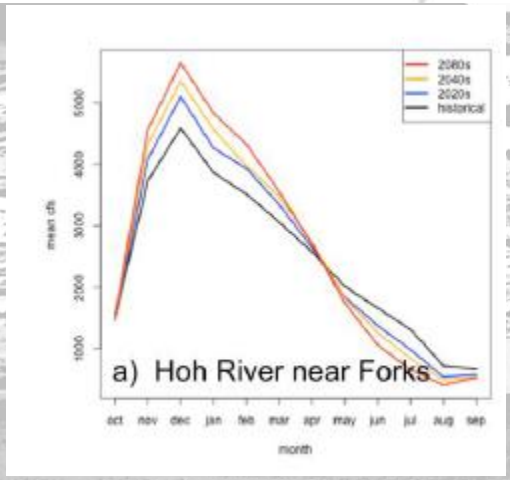


> Storminess?

Physical Drivers

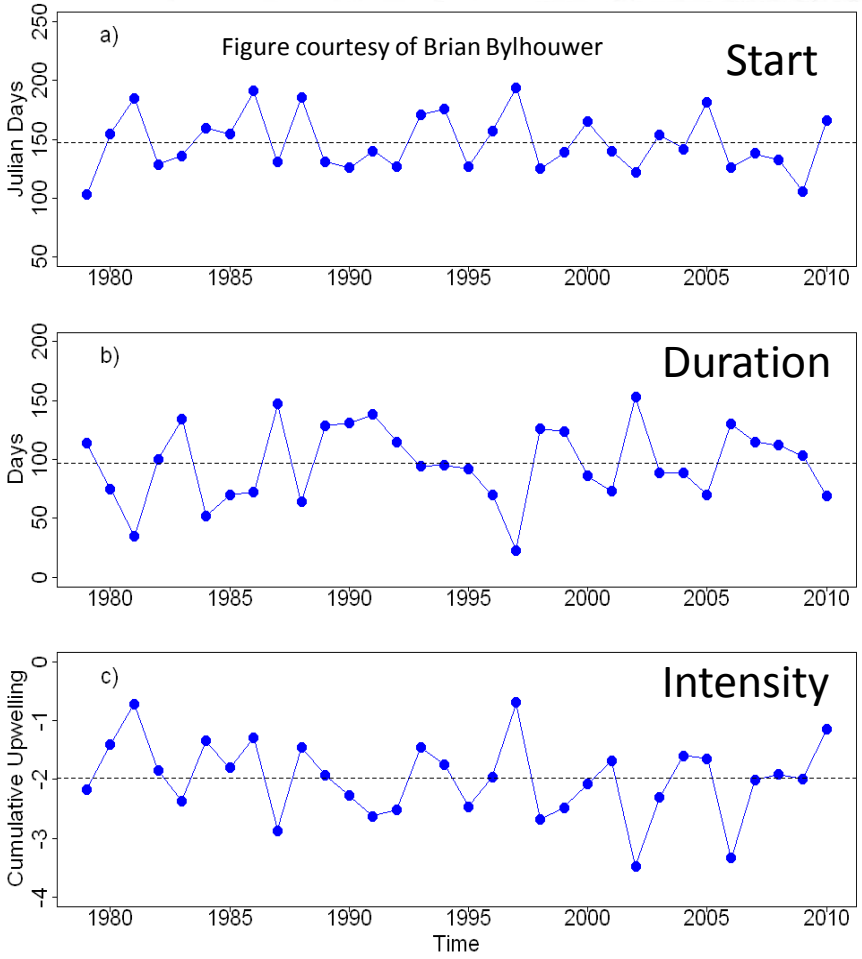
< Oxygen





>Winter flood, <summer flow

1979-2010 from NARR data



No Change in Upwelling?

General Ecological Response

- Shifts in Community Composition, Competition, Survival

Evidence for shift in intertidal community composition on Tatoosh Island corresponding with <pH (Wootton et al. 2008)

- Altered Phenology

Shift in the timing of the spring bloom in Lake Washington associated with increasingly warm springs (Winder and Schindler, 2004)

General Ecological Response

- Non-Native Species Interactions

Non-native bivalves colonize empty niches in Willapa Bay (Reusink, et al. 2006)

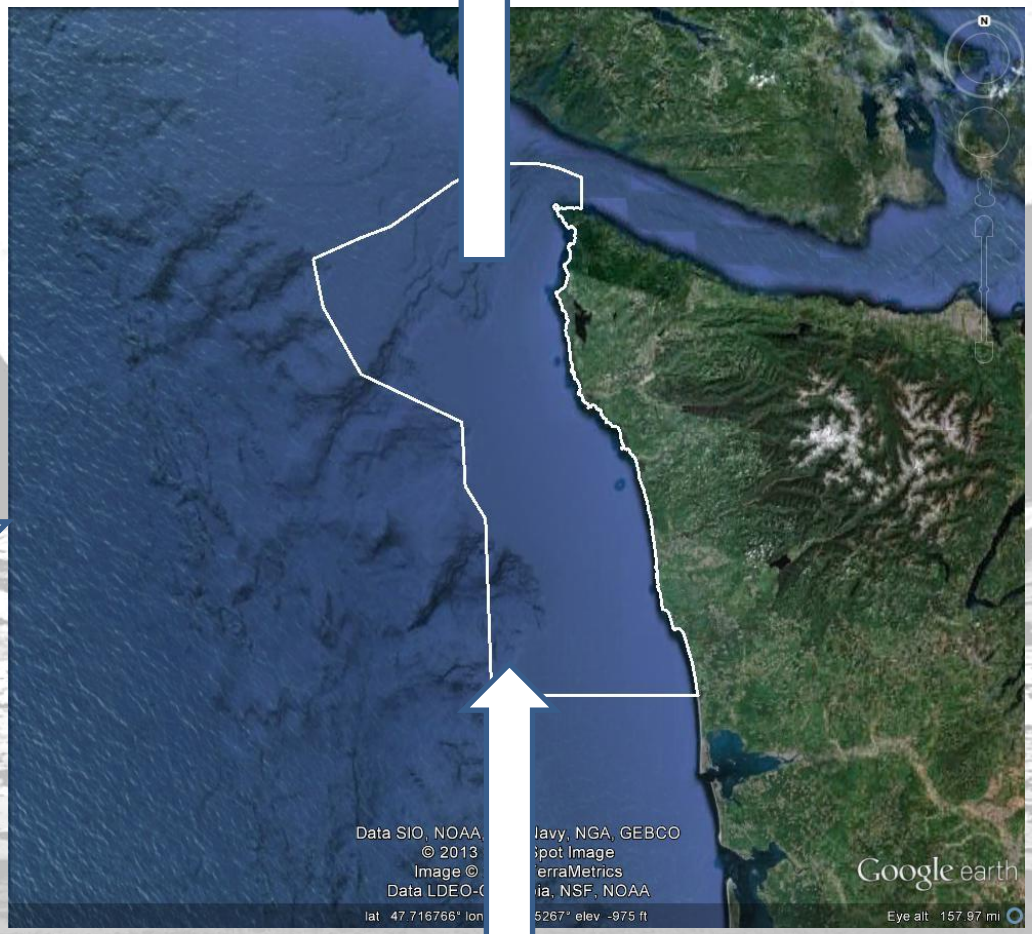
- Range Shifts

Northward range expansion of Humboldt Squid attributed in part to declining oxygen in NE Pacific Ocean (Bograd et al 2008)

“Cumulative” Implications…unclear?

5-10% of initial species lost by 2050

30% reduction in biomass of current species of commercial importance (NE Pacific)(Ainsworth et al 2011)

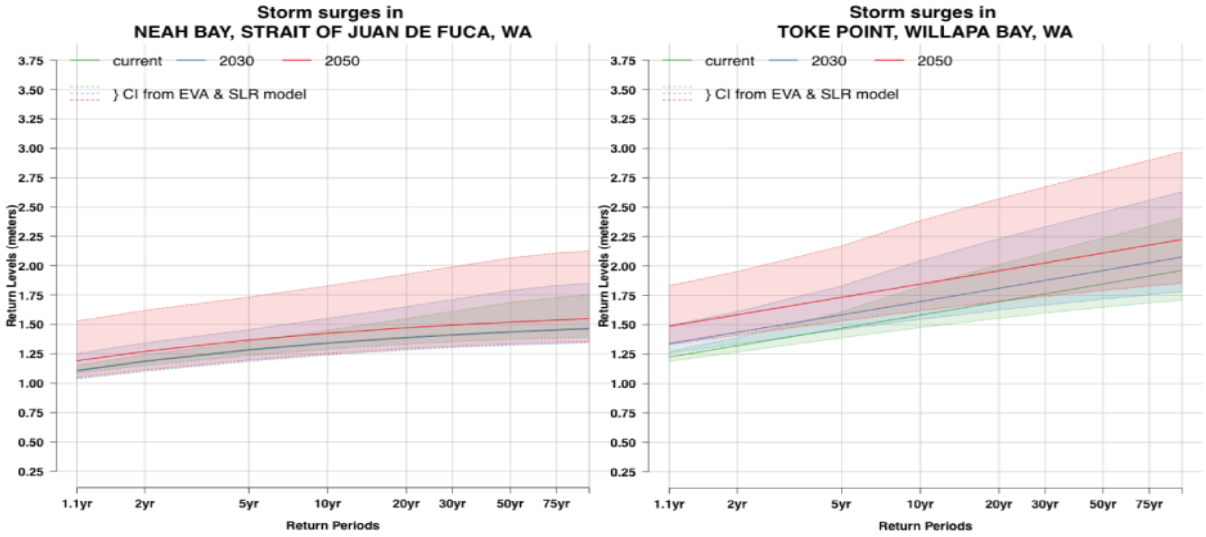


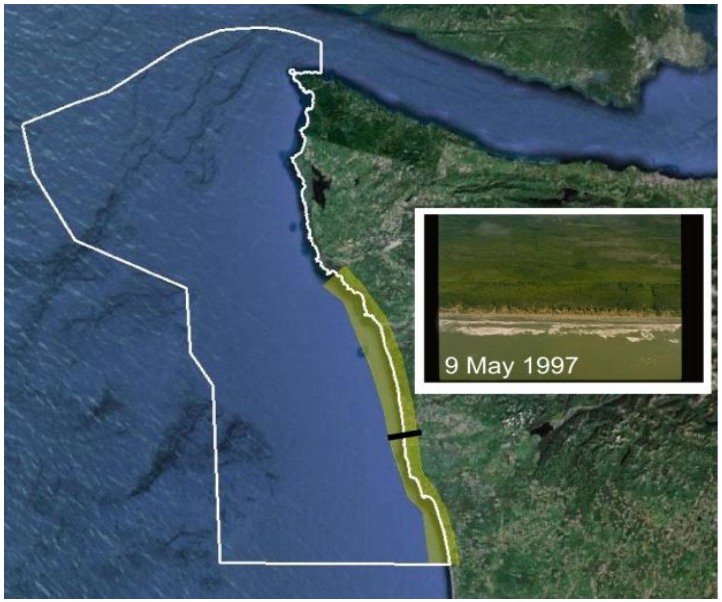
Cheung et al 2009

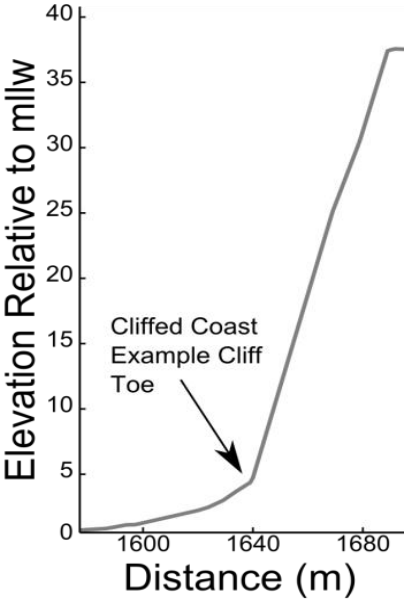
New species 15-60% of initial species

Habitat Implications

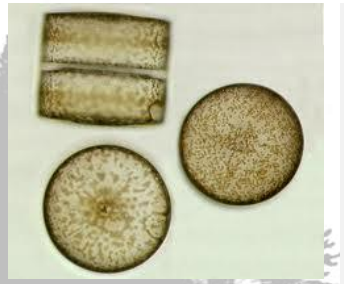
- Shallow Sub-tidal and Intertidal
  - Increased physical impact (shallow)
  - Shoreline erosion and re-distribution of sediment
  - Intertidal community re-structuring
- Deepwater Benthic
  - Temperature, hypoxia, surface productivty (upwelling) acidification.
  - Reduced habitat suitability for deepwater coral
- Pelagic Habitats
  - Pelagic fish declines, pelagic invertebrate increases
- Freshwater Habitats
  - Increase sediment supply due to winter high-flow?
  - No temperature affects on salmon, but scouring?







Species or Species Groups



Phytoplankton: Likely changes to bloom timing, duration and magnitude, increase in duration of “HAB” season (more in Puget Sound)

Zooplankton: Based on changes observed during El Nino years, possible shift to less nutritious community composition

Marine Algae: No clear direction in regards to populations. Both positive and negative consequences likely

Species or Species Groups

Deepsea corals: Possible stress due to OA, but there is some evidence that deepsea corals have adaptive capacity

Mussels: Both positive and negative consequences likely. Overall stress may increase mortality

Urchins: Both hypoxia and OA have been shown to stress urchin species. Magnitude of potential affect on population not clear

Species or Species Groups

Dungeness Crab: Various physical impacts of CC likely to impact all life stages, but overall impact to population not clear

Fish: Greatest stress expected on pelagic fish, less so for benthic fish.

Seabirds/Pinnipeds/Cetaceans: Overall impact to population likely very dependent upon response of prey species (small pelagic fish primarily) and their ability to shift predation to “new” species

NOTE: In No Way Have We Reduced Uncertainty

- Challenges
  - Inherent uncertainty in deriving climate projections, which is compounded in the marine environment
  - On top of that, variability in almost all parameters is HUGE and can swamp projected trends
  - The role played by climate cycles versus climate trends in the OCNMS is still not entirely clear.
  - Pushing projections up the trophic chain compounds the uncertainty even further
  - The OCNMS is a tiny slice of ocean, so inferences need to be made from research conducted at larger scales or in “similar” systems
  - Regionally down-scaled climate models are still in their infancy
  - Relative to some parts of the world research attention paid to this small slice of ocean is inadequate to provide insight into some of these big questions

Where are things at?

The goal of the climate smart sanctuary program is to "help a national marine sanctuary adapt to and mitigate for climate change impacts on its site resources and infrastructure"

OR, TO RESTATE

The goal is to reduce risk (the probability that harm will be experienced due to a perturbation or disturbance)

$$\text{Risk} = \text{Sensitivity} * \frac{\text{Vulnerability}}{\text{Adaptation Measures}} * \text{Impact}$$

What Is Risk?

Sensitivity captures how susceptible the resource is to damage due to climate change

Vulnerability is the ability of a resource to cope with climate change

$$\text{Risk} = \text{Sensitivity} * \frac{\text{Vulnerability}}{\text{Adaptation Measures}} * \text{Impact}$$

Adaptation Measures are actions designed to decrease vulnerability

Impact attempts to measure the “value” of the resource

What Have We Done?

Sensitivity captures how susceptible the resource is to damage due to climate change

Vulnerability is the ability of a resource to cope with climate change

$$\text{Risk} = \text{Sensitivity} * \frac{\text{Vulnerability}}{\text{Adaptation Measures}} * \text{Impact}$$

A Good Start on This

A little bit of this, but with uncertainty

Where Do You Need To Go?

Identifying these…we provide a kickstart

This is the tough bit

$$\text{Risk} = \text{Sensitivity} * \frac{\text{Vulnerability}}{\text{Adaptation Measures}} * \text{Impact}$$

Adaptation Measures are actions designed to decrease vulnerability

Impact attempts to measure the “value” of the resource

Continuing Steps

Draft Final Available At:

http://sanctuaries.noaa.gov/science/conservation/cc_ocnms.html

Final Expected in two weeks

Lara Whitely Binder from the Climate Impacts Groups will discuss some of the adaptation approaches and strategies in May….will that kickstart the climate action planning process?

Thanks!

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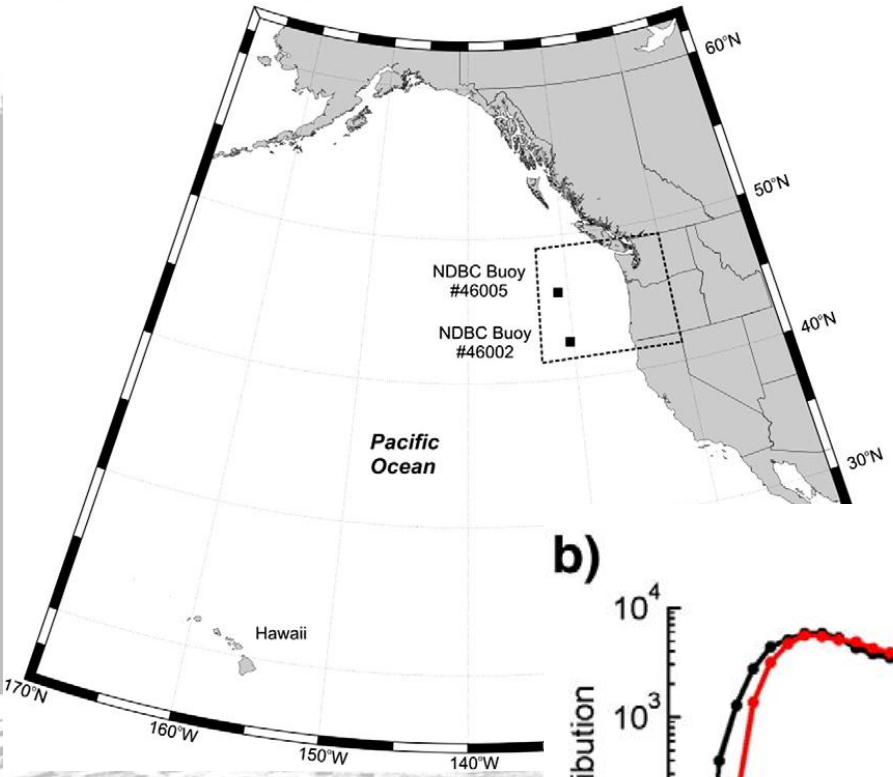
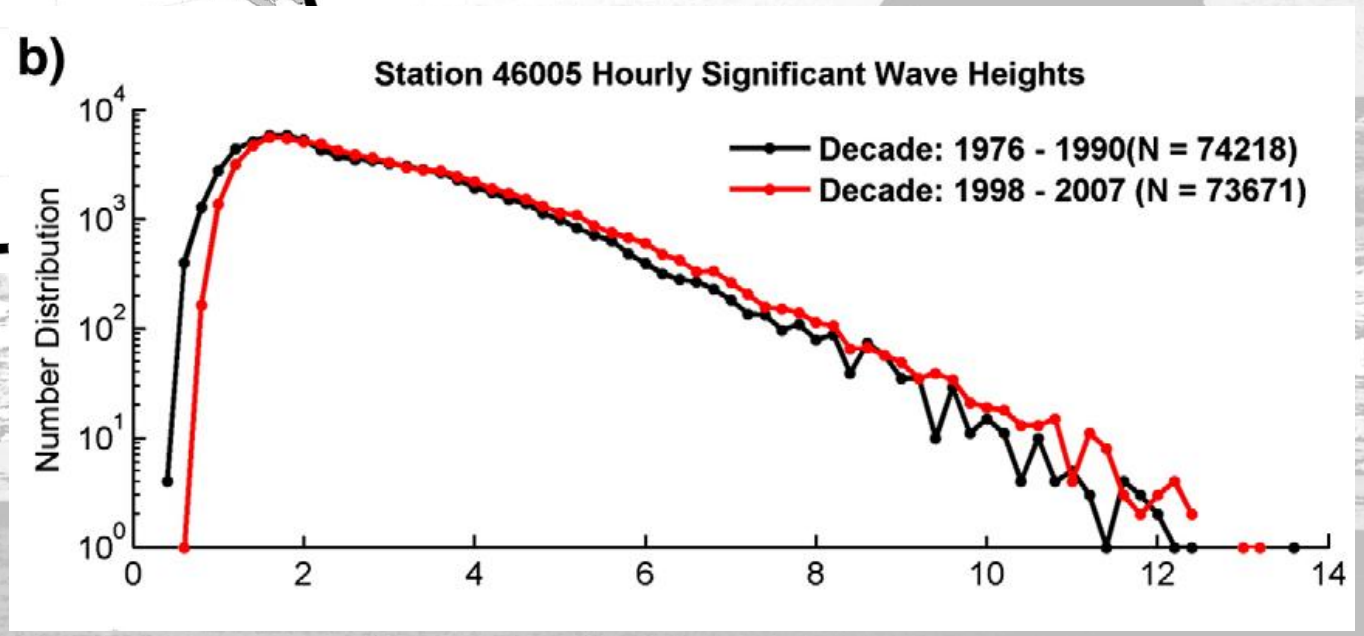
immiller@u.washington.edu

Image: Marine Stewardship Council

Wave Climate



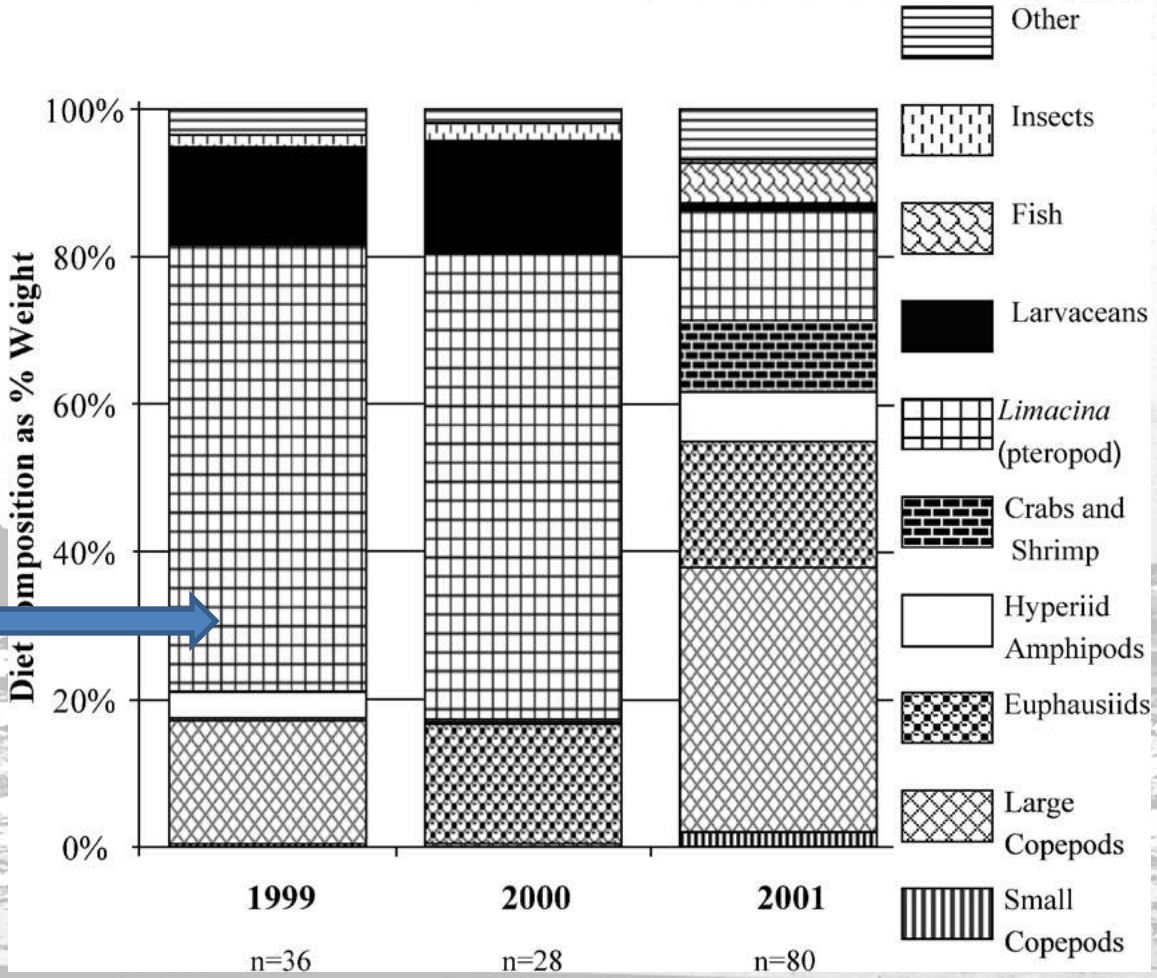
"uncertainty remains as to whether [these increases] are the product of human-induced greenhouse warming or represent variations related to natural multi-decadal climate cycles. Whatever the cause, the increases are important in their impacts ranging from ship safety to enhanced coastal hazards"



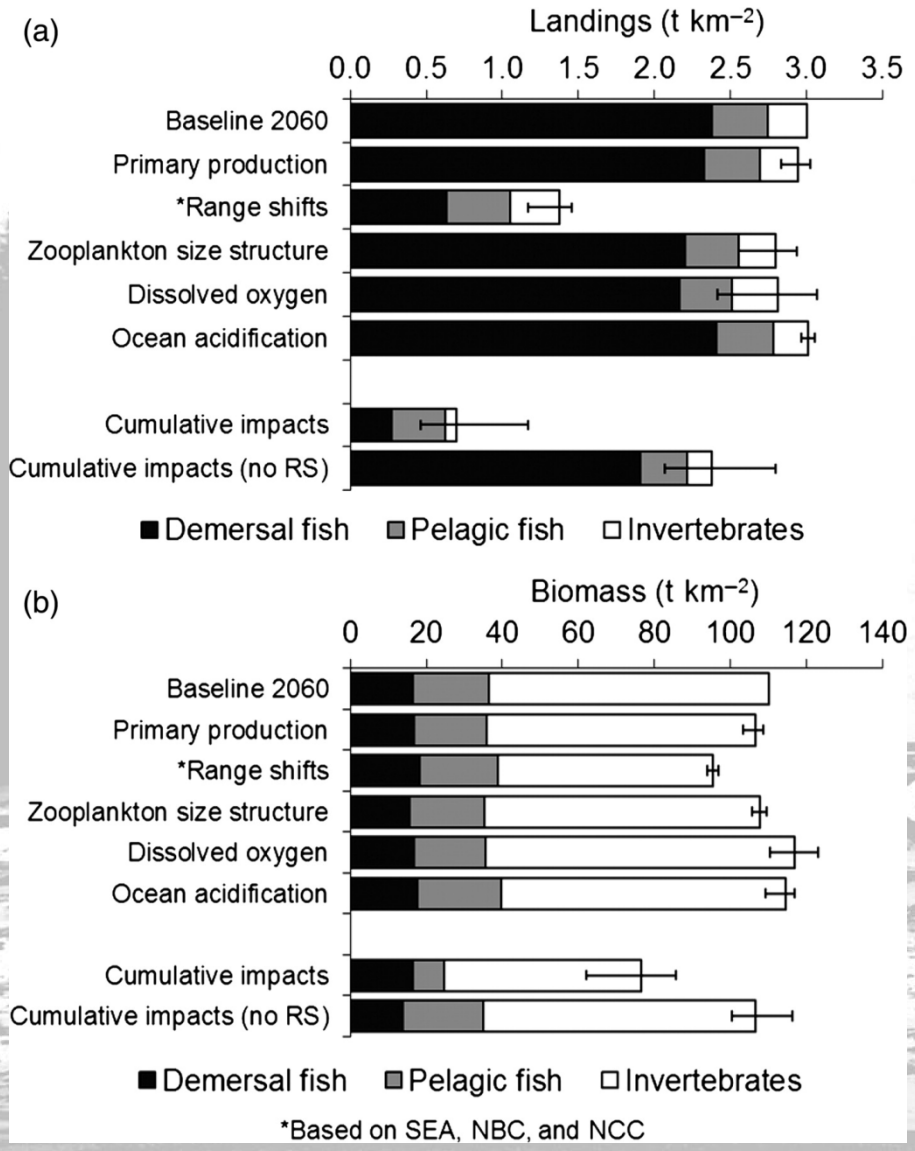
Ruggiero et al, 2010

Biological Communities

Gulf of Alaska Juvenile Pink Salmon Prey Distribution



Armstrong et al. 2005


(a)
Landings (t km⁻²)
0.0 0.5 1.0 1.5 2.0 2.5 3.0 3.5
Baseline 2060
Primary production
*Range shifts
Zooplankton size structure
Dissolved oxygen
Ocean acidification
Cumulative impacts
Cumulative impacts (no RS)
Demersal fish
Pelagic fish
Invertebrates
(b)
Biomass (t km⁻²)
0 20 40 60 80 100 120 140
Baseline 2060
Primary production
*Range shifts
Zooplankton size structure
Dissolved oxygen
Ocean acidification
Cumulative impacts
Cumulative impacts (no RS)
Demersal fish
Pelagic fish
Invertebrates
*Based on SEA, NBC, and NCC